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Non-volant mammals, Reserva Particular do Patrimônio Natural (RPPN) Rio das Pedras, municipality of Mangaratiba, state of Rio de Janeiro, Brazil

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Abstract
The Atlantic Forest is recognized as a global hotspot for having one of the highest rates of endemism and biodiversity. Its portion in the state of Rio de Janeiro is extremely fragmented and reduced. The present study seeks to get information on the non-volant mammals of RPPN *Rio das Pedras* in municipality of Mangaratiba, state of Rio de Janeiro. The rapid mammal's survey was accomplished by the use of pitfalls, live traps, transects and camera traps. We recorded 23 non-volant species that represent 13.1 % of Rio de Janeiro's terrestrial mammal species. Among the recorded species, five are endemic of the Atlantic Forest and three are in the state list of threatened or presumably threatened species. The area presents great mammal richness, but the hunting activity and the presence of exotic species may represent a threat to the local biodiversity and should be controlled.

Introduction

The Atlantic Forest is recognized as a global hotspot for having one of the highest rates of endemism and biodiversity of the planet (Myers et al. 2000). In Brazil, the Atlantic Forest is located throughout the coastal zone, where most of the Brazilian population is found (IBGE 2000). This peculiarity creates great pressure caused by the processes of urbanization and industrialization (Bergallo et al. 2000; Fundação SOS Mata Atlântica and Renctas 2005).

Today there are 11.7 % of Atlantic Forest's original cover left, of which 1.62 % are protect by conservation units of integral protection (Ribeiro et al. 2009). In the state of Rio de Janeiro, there are 27 units of integral protection (258,359.4 ha), 69 units of sustainable use (363,983.0 ha), of which 47 are *RPPN - Reserva Particular do Patrimônio Natural* (5,621.19 ha) (Uzêda et al. 2009). Even suffering these processes of degradation and fragmentation, the Atlantic Forest presents a large number of mammalian species. Along its extension 270 species are found, 90 of them being endemic (Fundação SOS Mata Atlântica and Renctas 2005).

The state of Rio de Janeiro has 19.6 % of its area covered by vegetation of Atlantic Forest, including remaining forests and associated ecosystems (Fundação SOS Mata Atlântica and INPE 2009). It holds 175 mammalian species, what represents 74 % of the Atlantic Forest mammalian species (Rocha et al. 2004; Esbérard and Bergallo 2005). Even though it holds a great proportion of Atlantic Forest mammals, the state of Rio de Janeiro has a shortage on faunal inventories in some of its regions (sensu Saraça et al. 2009), mainly in the agricultural regions of Pomba, Muriaé and Itabapoana rivers (*região Agropecuária dos Rios Pomba, Muriaé e Itabapoana*), the touristic region of the middle Paraíba river (*região Turístico-Cultural do Médio Paraíba*) and the mountain region with agricultural economy (*região Serrana de Economia Agropecuária*; Bergallo et al. 2009).

This work aims to provide a list of non-volant mammal species of the *RPPN Rio das Pedras*, analyzing aspects of the small mammal community structure, contributing to increase the knowledge on the fauna of the state of Rio de Janeiro.

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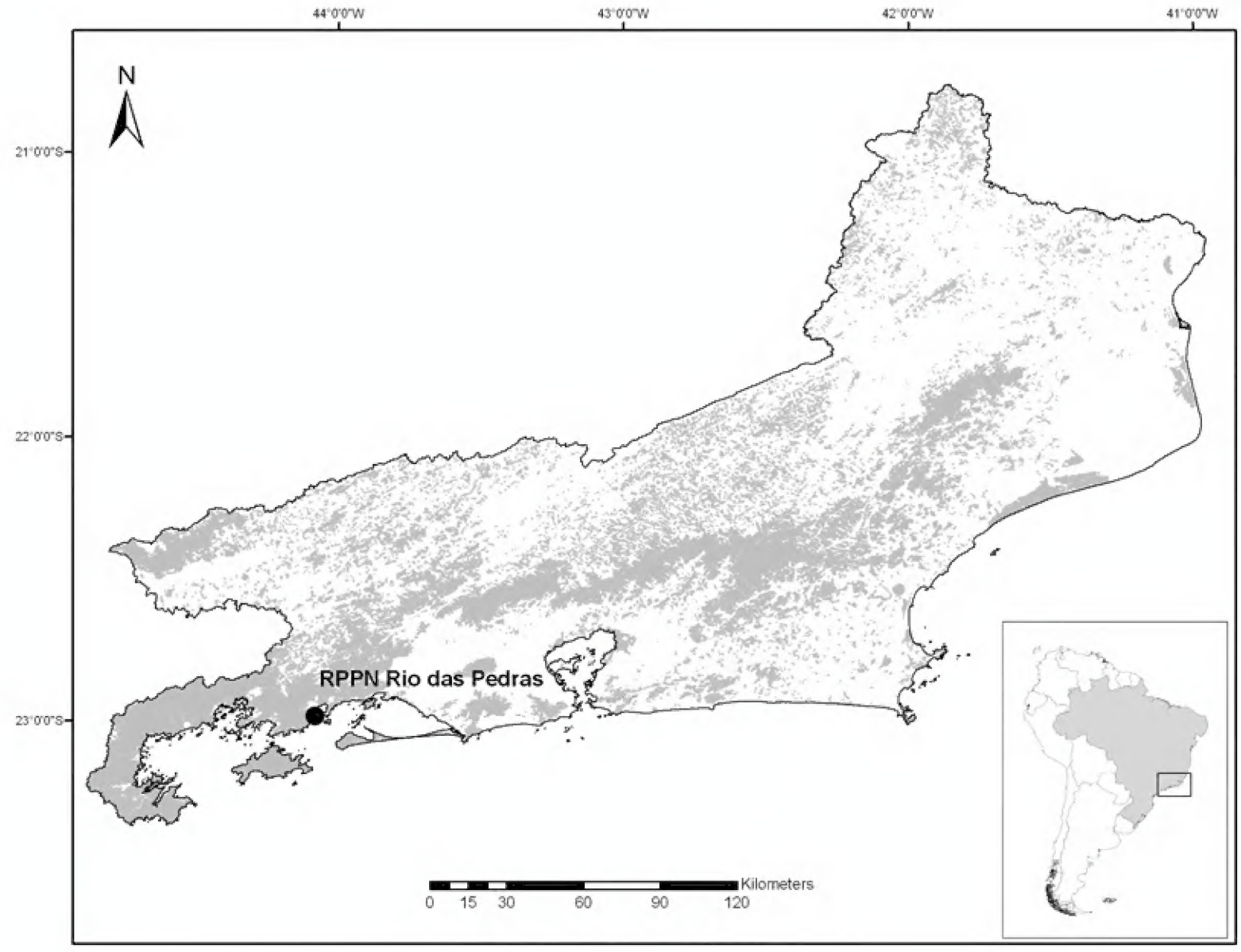

Figure 1. Location of RPPN *Rio das Pedras*, municipality of Mangaratiba, state of Rio de Janeiro, Brazil. The gray areas represent the vegetation remnants in Rio de Janeiro State.

Materials and Methods

Study Site

RPPN *Rio das Pedras* is located in municipality of Mangaratiba in the coordinates 22°59' S 44°05' W in the touristic region of Costa Verde (Figure 1). The Reserve has 1,360 ha and its altitude varies between 20 and 1,050 m (Mynssen and Windisch 2004), although this study was carried out only from 25 to 700 m. It is a Private Reserve of Natural Patrimony and it is property of Club Mediterranée from Brazil. The annual average temperature is 22 °C, with maximum of 38 °C and minimum of 12 °C. The highest rainfall rates occur between December and February (Mynssen and Windisch 2004). The vegetation type in the study area is Evergreen Dense Forest (Radam Brasil 1983).

Data Collection

The inventory occurred from 6 to 12 August 2005. The capture of small mammals was accomplished with 126 live traps, 94 Sherman® (30.48 x 9.52 x 7.62 cm) and 32 Tomahawk® (40.00 x 12.00 x 12.00 cm), being 90 of them set on the ground and 36 on trees. We divided the traps in three distinct lines that were separated from each other with a distance over 100 m. In each line, we set 30 traps on the ground, 40 m apart from each other, and 12 on the trees, 100 m from each other and at a minimum height of 2 m. The lines encompassed different altitude ranges, being the first one set between 25 and 175 m, the second one between 35 and 530 m, and the last one set in a plateau at 700 m of altitude. Traps were baited with banana, bread moistened with sunflower oil and a mixture of banana, peanut butter, corn flour and sardine oil. The baits were used alternately in each trap. The traps were opened during six consecutive nights with a total effort of 756 trap-nights. All traps were checked in the morning and had their baits replaced if necessary. After the third sampling night the traps on the ground were moved 20 m forward in the line, aiming increasing the environmental gradient sampled.

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Rodents and marsupials were also sampled with pitfall traps. We used 30 buckets of 30 liters divided in three systems. In each system we set 10 buckets buried in the ground, five meters apart from each other, connected by a soft plastic drift fence, 50 cm height. The pitfall traps were installed in tracks near to the lines where the conventional live traps were set, with a minimum distance of 30 m from them. These traps were opened during six consecutive nights and were checked daily during the morning. The total effort of these traps was of 180 bucket-nights.

The mammals captured were identified following Wilson and Reeder (2005) and Weksler et al. (2006), marked with ear holes and released in the same point of capture. Some specimens were collected and deposited as voucher specimens (License # 89/05-RJ IBAMA) in *Museu Nacional do Rio de Janeiro* (Appendix).

The rarefaction and accumulation curves of small mammal species, captured in Sherman® and Tomahawk® traps, were created in the software EstimateS 8.0.0 (Colwell 2006). For the rarefaction curves 1,000 randomizations were done.

We registered medium and large mammals with four analogical camera traps that were set along the study area. We put the cameras on pre-existing trails of animals in the forest at a minimum distance of one kilometer from each other. We used banana and sardine as baits and replaced them as many times as necessary. The traps remained in the area for 33 days, with a total effort of 984 h. Medium and large mammals were also recorded in linear transects. Transects were done in tracks in the forest mostly during sundown/twilight and by night, with a total of 24 km covered with a mean speed of 1 km/h, by five observers. The large mammals were registered by visualization, vocalization, footprints, feces and other vestiges, occasionally recorded when the observers were crossing the transect lines during the day and the night.

We also interviewed the employees of the Reserve about species occurrence. The recognition of these species was based on illustrations and photos of specialized literature (Emmons and Feer 1990; Eisenberg and Redford 1999), always considering the distribution and occurrence of the species for the considered region.

Results and Discussion

We registered 23 mammal species, being six from the order Didelphimorphia, one from the order Pilosa, three from the order Carnivora, two from the order Primates, ten from the order Rodentia and one from the order Lagomorpha (Table 1). The species from RPPN *Rio das Pedras* correspond to 9.2 % of the Atlantic Forest terrestrial mammals, and 13.1 % of state of Rio de Janeiro (Rocha et al. 2004; Esbérard and Bergallo 2005; Reis et al. 2006). Furthermore, five of the recorded species are endemic to the Atlantic Forest (Fonseca et al. 1996). The Atlantic Forest endemic species recorded were *Didelphis aurita* (Wied-Neuwied, 1826), *Marmosops incanus* (Lund, 1840), *Philander frenatus* (Olfers, 1818), *Oxymycterus dasytrichus* (Schinz, 1821) and *Trinomys dimidiatus* (Günter, 1877) (Fonseca et al. 1996).

Through the reports of employees of the Reserve we registered the presence of one species, *Dasyprocta leporina* (Linnaeus, 1758), that was not detected by the conventional sampling methods used. The occurrence of *D. leporina* in the Reserve is possible, since this species presents a large geographic distribution that encompasses the studied area (Eisenberg and Redford 1999; Reis et al. 2006). We registered 22 species with conventional sampling methods, being seven of these registered exclusively with Sherman® and Tomahawk® live traps, seven exclusively by sightings, two only by camera traps and one by vestiges. No species has been recorded in the pitfalls traps.

Considering the species registered through Sherman® and Tomahawk® live traps, pitfalls, camera traps, sightings and tracks, the richness of mammals found in RPPN *Rio das Pedras* is similar to the one registered at *Parque Estadual do Desengano* (24 species; Modesto et al. 2008a) and at *Santuário da Vida Silvestre da Serra da Concórdia* (20 species; Modesto et al. 2008b) (Table 2). Both of the mentioned areas had the same effort and sampling design than the one applied in the present study.

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Table 1. Non-volant mammal species of RPPN *Rio das Pedras*, respective type of record and degree of threat. The codes for registration are: CT (camera traps), Ca (capture), In (interviews), Si (sighting), Tr (tracks that indicate the presence of the species). Codes for threat Degree: PT (Presumably threatened), Vu (Vulnerable). Degree of threat according to Bergallo et al. (2000) and Chiarello et al. (2008).

			Degree of threat	
		Type of record	Rio de Janeiro	Brazil
Order Didelphimorphia				
	Family Didelphidae			
1	*Chironectes minimus* (Zimmerman, 1780)	Si	PT	
2	*Didelphis aurita* (Wied-Neuwied, 1826)	Ca/CT/Si		
3	*Marmosops incanus* (Lund, 1840)	Si		
4	*Metachirus nudicaudatus* (É. Geoffroy, 1803)	Ca		
5	*Micoureus paraguayanus* (Tate, 1931)	Ca/Si		
6	*Philander frenatus* (Olfers, 1818)	Ca/CT		
Order Pilosa				
	Family Myrmecophagidae			
7	*Tamandua tetradactyla* (Linnaeus, 1758) (Figure 2)	Si		
Order Carnivora				
	Family Canidae			
8	*Canis lupus* Linnaeus, 1758	CT		
9	*Cerdocyon thous* (Linnaeus, 1766) (Figure 3)	CT		
	Family Felidae			
10	*Puma concolor (*Linnaeus, 1771)	Tr	VU	VU
Order Primates				
	Family Cebidae			
11	*Callithrix jacchus* (Linnaeus, 1758)	Si		
12	*Callithrix penicillata* (É. Geoffroy, 1812) (Figure 4)	Si		
Order Rodentia				
	Family Sciuridae			
13	*Sciurus aestuans* Linnaeus, 1766	Si		
	Family Cricetidae			
14	*Akodon cursor* (Winge, 1887)	Ca		
15	*Euryoryzomys russatus* Wagner, 1848	Ca		
16	*Hylaeamys laticeps* (Lund, 1840)	Ca		
17	*Nectomys squamipes* (Brants,1827)	Ca		
18	*Oxymycterus dasytrichus* (Schinz,1821)	Ca		
19	*Rhipidomys* sp.	Ca		
	Family Erethizontidae			
20	*Sphiggurus villosus* (F. Cuvier, 1823)	Si	VU	VU
	Family Dasyproctidae			
21	*Dasyprocta leporina* (Linnaeus, 1758)	In		
	Family Echimyidae			
22	*Trinomys dimidiatus* (Günter, 1877)	Ca/CT		
Order Lagomorpha				
	Family Leporidae			
23	*Sylvilagus brasiliensis* (Linnaeus, 1758)	Si/CT		

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Figure 2. *Tamandua tetradactyla.* Photo by F. S. Pessôa.

Figure 3. *Cerdocyon thous* in camera trap.

From all species registered in the RPPN *Rio das Pedras*, three are found in the Rio de Janeiro's threatened species list (Table 1), one in the presumably threatened category, and two in the vulnerable category (Bergallo et al. 2000). From the Brazilian list of threatened fauna, we registered two species (Table 1) in the vulnerable category (Chiarello et al. 2008).

Among the small mammals, the most captured species in Sherman® and Tomahawk® traps were *T. dimidiatus* (Günther, 1877), and the ones from the Oryzomyini tribe [*Euryoryzomys russatus* Wagner, 1848 and *Hylaeamys megacephalus* (Lund, 1840), excluding *Nectomys squamipes* (Brants, 1827)] with 15 and 14 captures, respectively (Figure 5). Among the least captured species, we found *Micoureus paraguayanus* (Tate, 1931), *Akodon cursor* (Winge, 1887) and *O. dasytrichus* with three captures each, *Rhipidomys* sp. and *Nectomys squamipes* with one capture each (Figure 5).

The pitfall traps had no captures. The high number of captures of *T. dimidiatus* compared to other species is expected, since the species from the genus *Trinomys* have a broad distribution in Brazil (Lara et al. 2002) and are very common in faunal inventories, especially in the Atlantic Forest (e.g. Pereira et al. 2001; Geise et al. 2004; Vaz 2005; Modesto et al. 2008a; Modesto et al. 2008b). As suggested by Brown (1984), there is a positive relationship between distribution and abundance of species. This seems to be the case of *Trinomys dimidiatus* that showed a potential distribution encompassing a great part of the state of Rio de Janeiro and part of São Paulo coast (Attias et al. 2009). If we analyze the rarefaction curve (Figure 6) it is possible to realize that a greater sampling effort is necessary to get closer to the real number of species that occur in the Reserve. Despite this fact, rapid surveys like this are essential to increase knowledge of mammal species and help to guide management inside nature reserves, such as RPPN.

Figure 4. *Callithrix penicillata.* Photo by T. C. Modesto.

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Table 2. Mammal richness by order in three different areas of the state of Rio de Janeiro using the same sampling methods: PED - *Parque Estadual do Desengano*, CONC - *Santuário da Vida Silvestre da Serra da Concórdia* and the present study in RPPN *Rio das Pedras*.

	Sherman and Tomahawk traps			**Pitfall traps**			**Sightings, camera traps and tracks**		
Order	CONC	PED	Present study	CONC	PED	Present study	CONC	PED	Present study
Didelphimorphia	2	4	4	1	1	0	5	2	5
Pilosa	0	0	0	0	0	0	0	0	1
Cingulata	0	0	0	0	0	0	1	0	0
Carnivora	0	0	0	0	0	0	5	1	3
Primates	0	0	0	0	0	0	0	2	2
Rodentia	3	13	7	3	8	0	3	3	3
Lagomorpha	0	0	0	0	0	0	1	0	1
Total	5	17	11	4	9	0	15	8	15

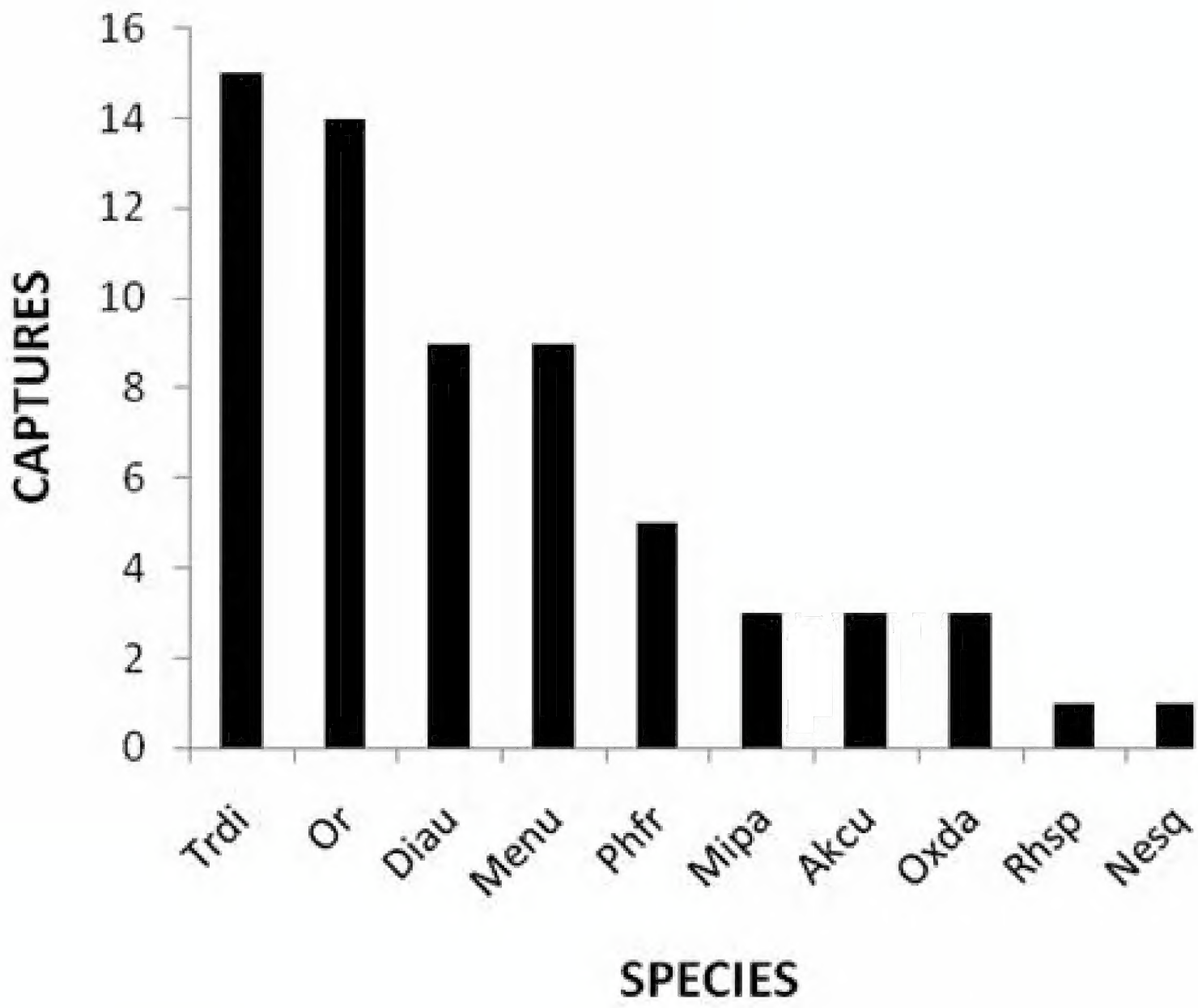

Figure 5. Number of individuals per species captured in Sherman and Tomahawk traps in RPPN *Rio das Pedras*. Trdi (*Trinomys dimidiatus*); Or (tribe Oryzomyini, excluding *Nectomys squamipes*); Diau (*Didelphis aurita*);

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Menu (*Metachirus nudicaudatus*); Phfr (*Philander frenatus*); Mipa (*Micoureus paraguayanus*); Akcu (*Akodon cursor*); Oxda (*Oxymycterus dasytrichus*); Rhsp (*Rhipidomys* sp.); Nesq (*Nectomys squamipes*).

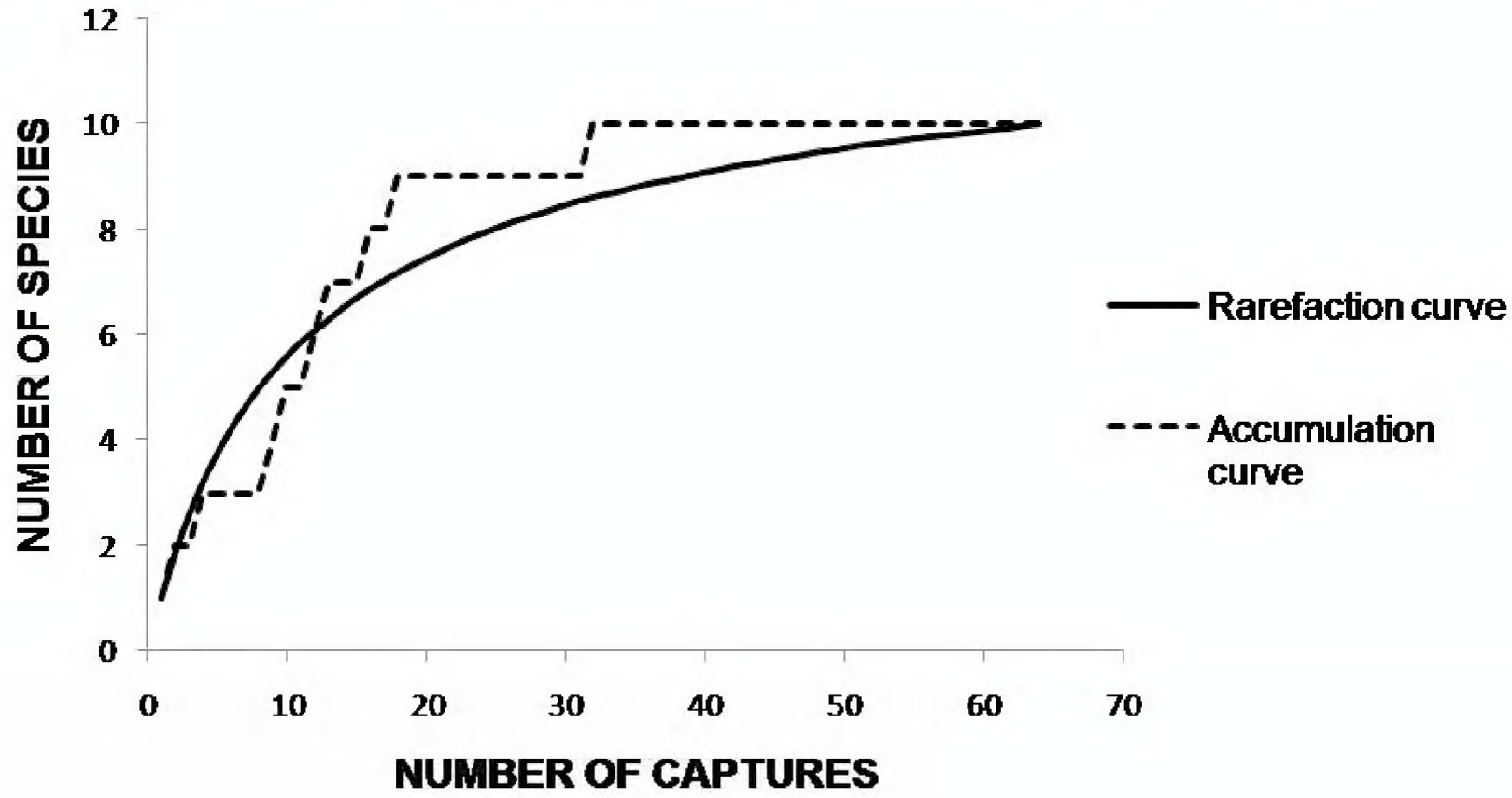

Figure 6. Accumulation and rarefaction curves of small mammal species from RPPN *Rio das Pedras* captured in live traps.

The exotic species *Callithrix jacchus* (Linnaeus, 1758), *Callithrix penicillata* (É. Geoffroy, 1812) (Figure 4) and their hybrids were also registered in the Reserve, besides the domestic dog, registered by camera traps. The presence of mixed groups of the exotic species *C. jacchus* and *C. penicillata* is a potential threat to the local fauna and flora where they were introduced, since these species can act as predators of small vertebrates and invertebrates, besides damaging tree trunks and woody vines to feed on exudates (Coimbra-Filho 1972; Silva and Cruz 1993; Rylands 1996; Digby and Barreto 1998; Castro et al. 2000; Castro 2003). Another impact that can be caused by these exotic primates is the hybridization with other species of the genus, such as *Callithrix aurita* (É. Geoffroy, 1812) (Coimbra-Filho 1971; Coimbra-Filho et al. 1993). Although not recorded, *C. aurita* distribution can potentially encompass the RPPN *Rio das Pedras* (Rylands et al. 2008). The occurrence of feral dogs in areas of preserved forest is also a serious impact for wildlife, because they prey many species of vertebrates (Galetti & Sazima, 2006). Measures aiming the eradication of these species in the region should be implemented urgently, since a fast and intense action is the best way to deal with exotic invasive populations (Simberloff 2003).

Evidence of hunting activities has been found in the Reserve, such as *jirau* (a tree waiting platform made by hunters) and old hunting traps. Based on our inventory, the RPPN *Rio das Pedras* has problems concerning hunting activity and the presence of exotic species that may represent impacts to the local biodiversity. The increase of surveillance might be an efficient measure to control hunting activities and illegal extraction in the Reserve. The occurrence of exotic primates is a threat to the local biodiversity and its control or eradication must be done.

The richness of RPPN *Rio das Pedras* and the presence of some threatened species, such as *P. concolor*, emphasize the importance of this Reserve. Despite being in a well sampled region, new studies should be developed to manage the population of some species and to record new ones in order to increase the knowledge on the mammal fauna of the state of Rio de Janeiro.

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Acknowledgements

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LISTS OF SPECIES

Appendix. Voucher list of the species collected at RPPN *Rio das Pedras* deposited in the collection of *Museu Nacional do Rio de Janeiro*, Rio de Janeiro, Brazil: *Akodon cursor* (MN 71832, 71833), *Euryoryzomys russatus* (MN 71835, 71836), *Hylaeamys laticeps* (MN 71834), *Oxymycterus dasytrichus* (MN 71831), *Trinomys dimidiatus* (MN 70157).

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LISTS OF SPECIES

Non-volant mammals, Reserva Particular do Patrimônio Natural (RPPN) Rio das Pedras, municipality of Mangaratiba, state of Rio de Janeiro, Brazil

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On page 581, last line of left column *Hylaeamys laticeps* was misidentified as *Hylaeamys megacephalus*. We apologize and are grateful for your comprehension.